VIIRS Marine Isoprene:
From Research to Air Quality Forecasting Operation

Daniel Tong and Pius Lee
NOAA Air Resources Laboratory (ARL), College Park, MD

Menghua Wang and Xiaoming Liu
NOAA Center for Satellite Applications and Research (STAR), College Park, MD

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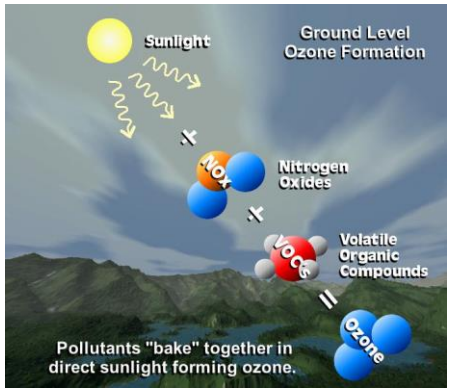
What is isoprene

Isoprene ($CH_2=CH-C(CH_3)=CH_2$) is a biogenic hydrocarbon emitted by trees, grasses and ocean phytoplankton.

- **Purpose of emission:** combat abiotic stresses;
- **Ozone formation:**

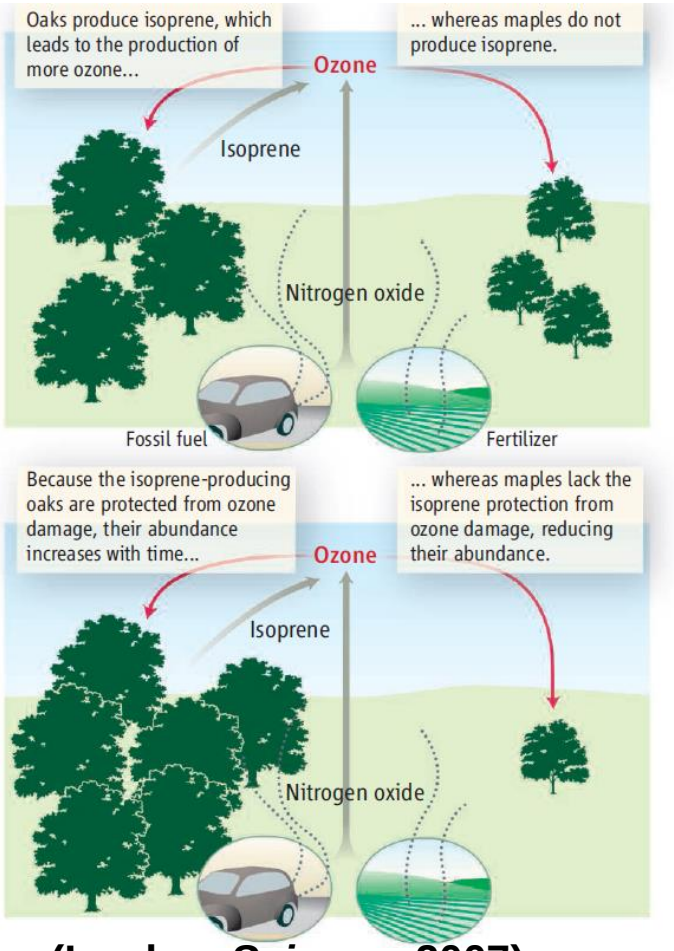


- **Aerosol formation:**

$$\mathrm{VOC} + \mathrm{OX} \rightarrow \sum_{i=1}^{N} \alpha_i \times P_i \rightarrow \mathrm{SOA}$$

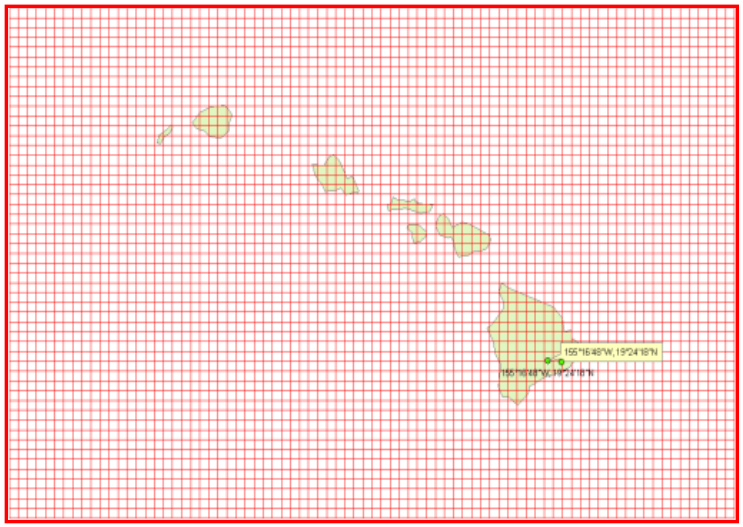
- **Cloud formation:** Cloud Condensation Nuclei (CCN);

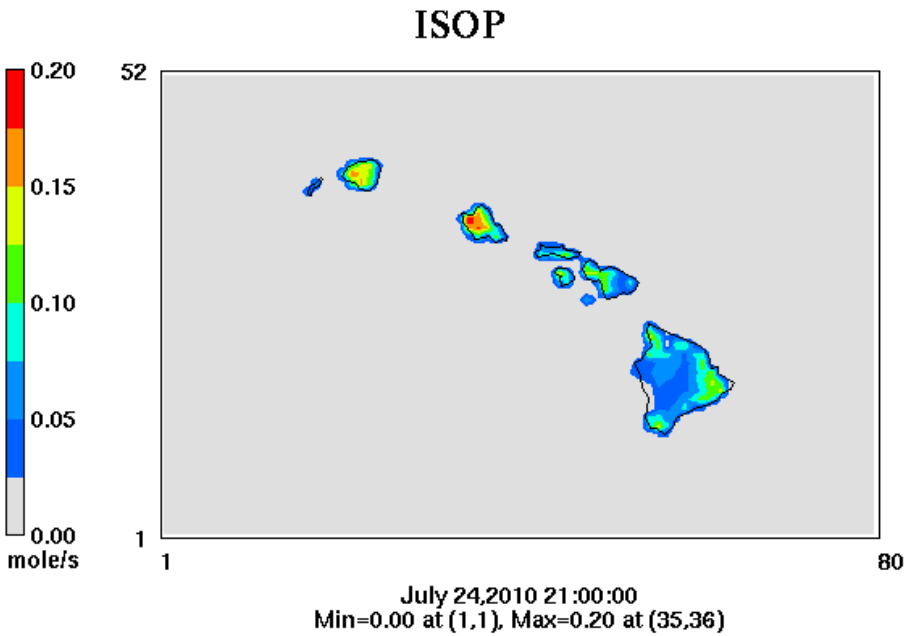
Ozone, Aerosol, cloudiness all at the central stage of climate change debate



(Lerdau, *Science*, 2007)

National Air Quality Forecast over Hawaii

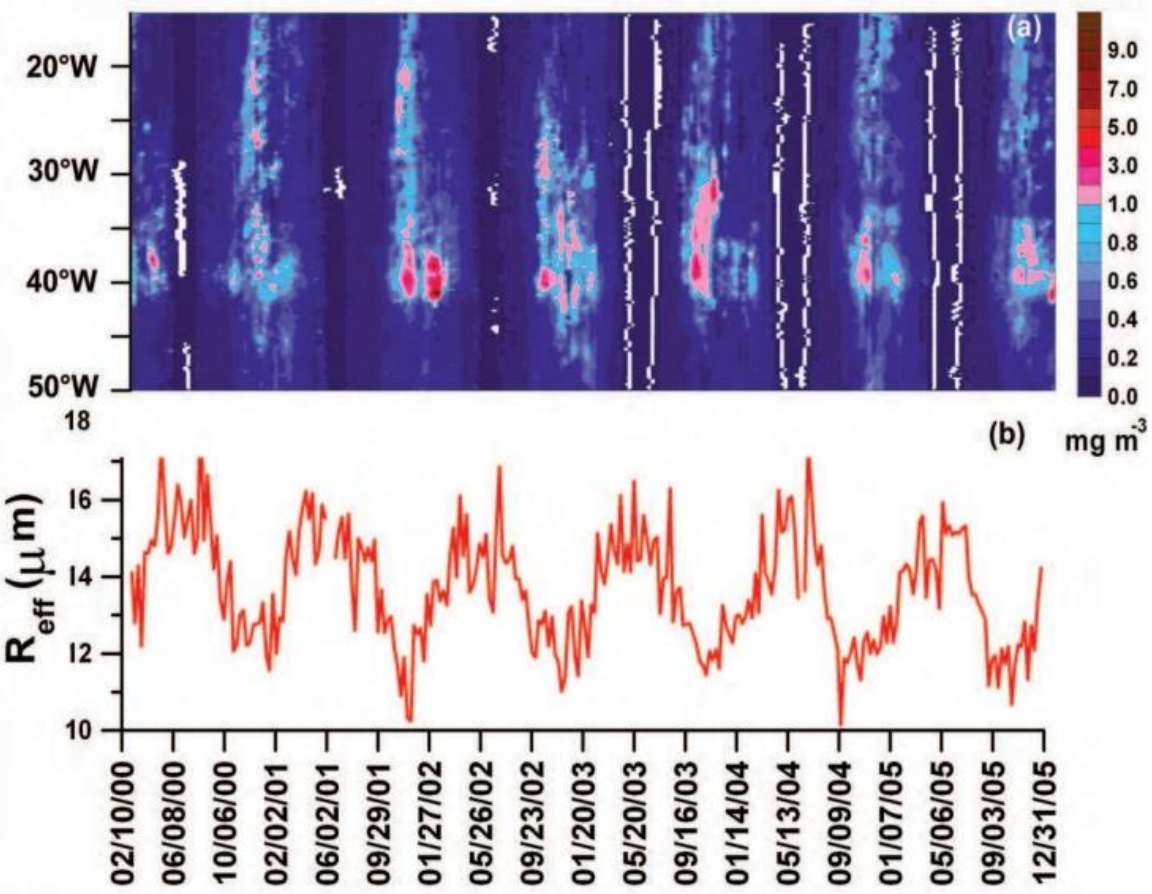




A suite of reactive gases and aerosols emitted from the Ocean:

- **Isoprene;**
- **Dimethyl Sulfide (DMS);**
- **Organic Aerosols;**

Algae Bloom and Ocean Cloudiness



(Meskhidze and Nenes, Science, 2006)

JPSS marine Isoprene algorithm (V1.0)

- **Built upon several pioneering works:**

$$F = a' [Chl]' \sum_{i=1}^{N} (EF_i' f_i)' H_{max}' g$$

JPSS Products Used:

- **[Chl-a]**
- **Kd490**
- **PAR**

Euphotic zone height (Gantt et al., 2009)

$$H\max = (-\ln(\frac{2.5}{I_0}) / K_{490})$$

I_0 – ground radiation; K490 – defuse attenuation coefficient in water

Phytoplankton Functional Types (PFTs) (Arnold et al., 2009)

Determine emission factor (EF) and abundance (f);
No data available from JPSS, using SeaWiFS climatological data

Chlorophyll-a and $K_d(490)$

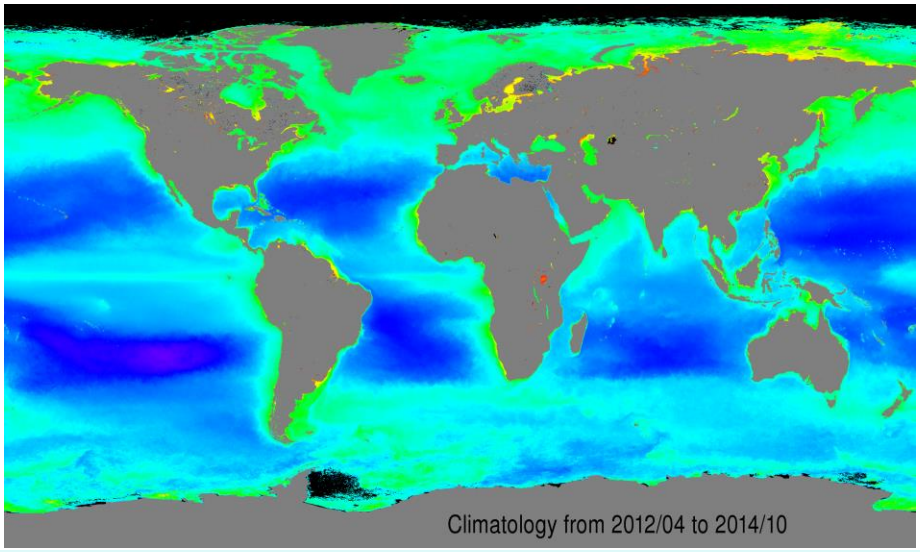
- **Sensor/Satellite**: Visible Infrared Imaging Radiometer Suite (VIIRS) on SNPP
- **Ocean Color Data Processing:**

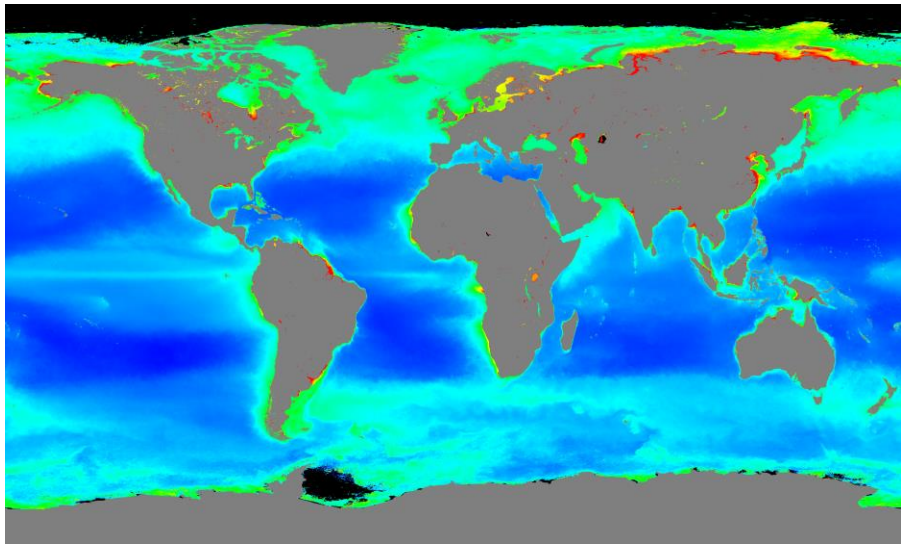
  - Multi-Sensor Level-1 to Level-2 (MSL12) is used for VIIRS ocean color data processing

  - Routine ocean color data production from SDR (Level-1B) to ocean color EDR (Level-2), and to global Level-3 data, including nL_w, chlorophyll-a, and $K_d(490)$.

  - Level 3: Products are mapped to the CoastWatch geographic regions

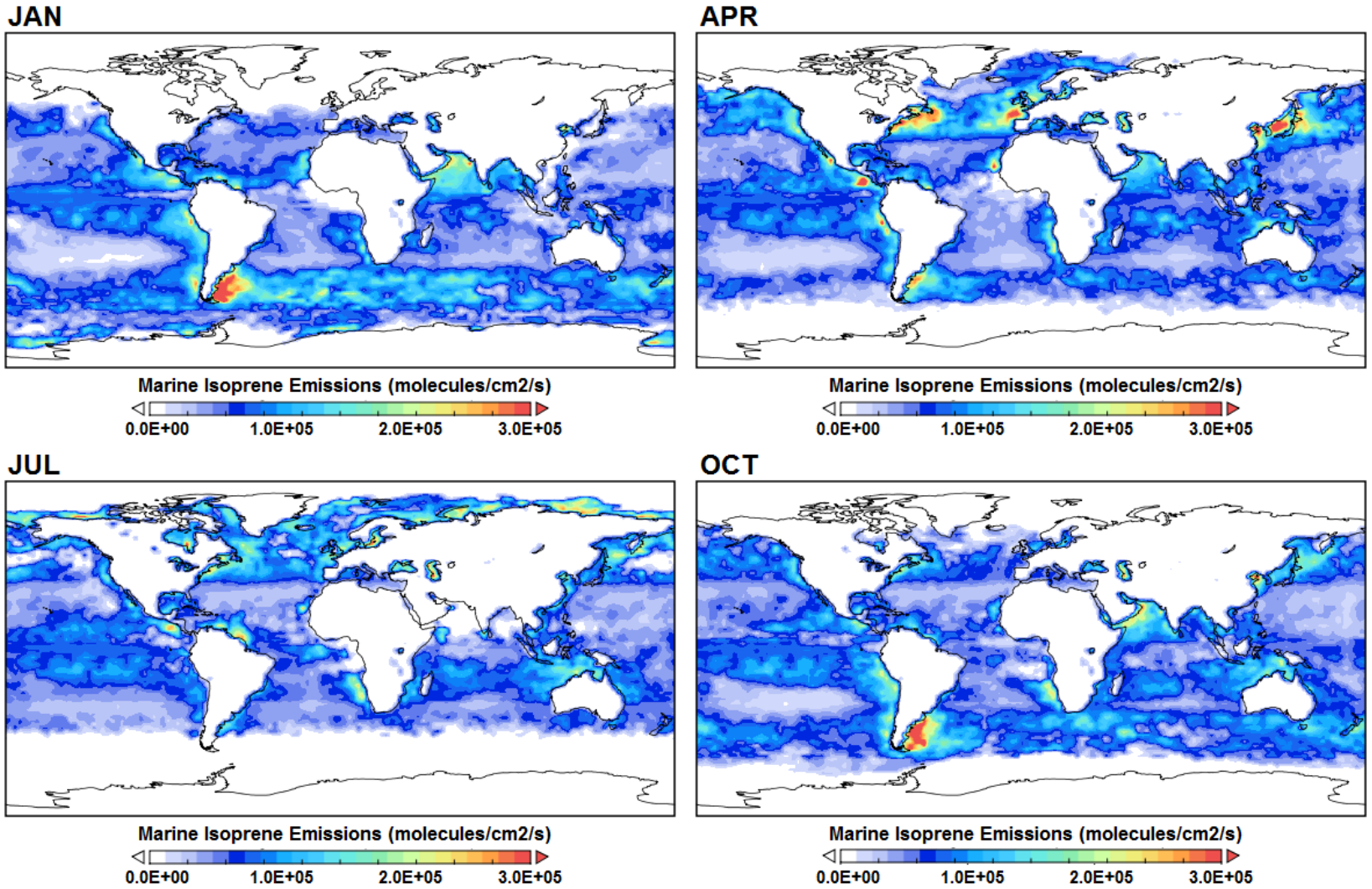
- **Algorithms (Ocean Color EDR Team):**
  - Chlorophyll-a concentration: VIIRS OC3 algorithm
  - Diffuse attenuation coefficient at 490 nm $K_d(490)$: *Wang et al.* (2009) algorithm





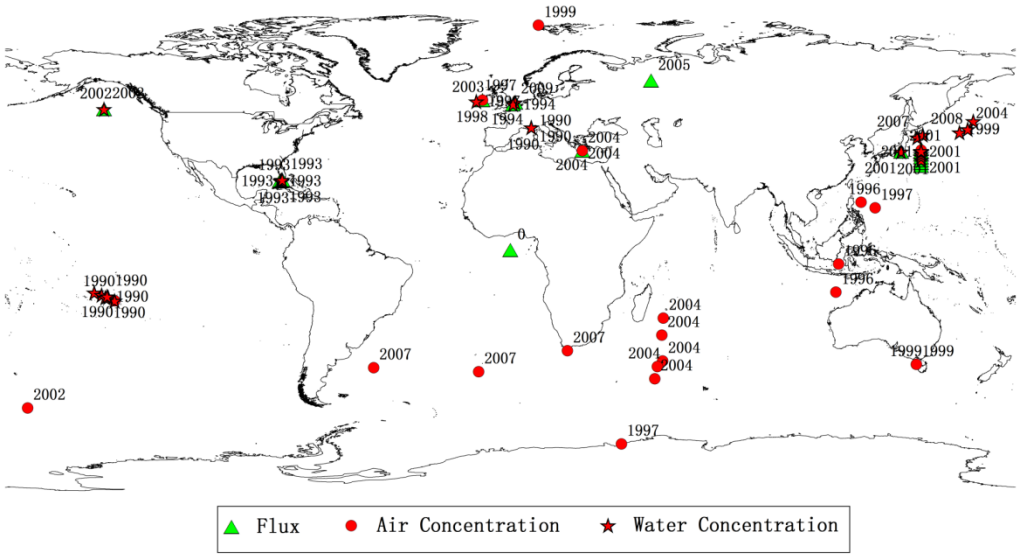
Chlorophyll-a **$K_d(490)$**

Global Distribution of Marine Isoprene



Isoprene Observations and Reprocessing

Issue: Some data can not be directly used for product validation.
Reprocessing Approach: Air-sea mass transfer.



Convert seawater conc into flux:

$$E_{iso} = K_{AS} * (C_W - H * C_A)$$

k_{AS} – exchange coeff.;

C_W – isop. conc. in water

C_A – isop. conc. in the air

H – Henry's law constant;

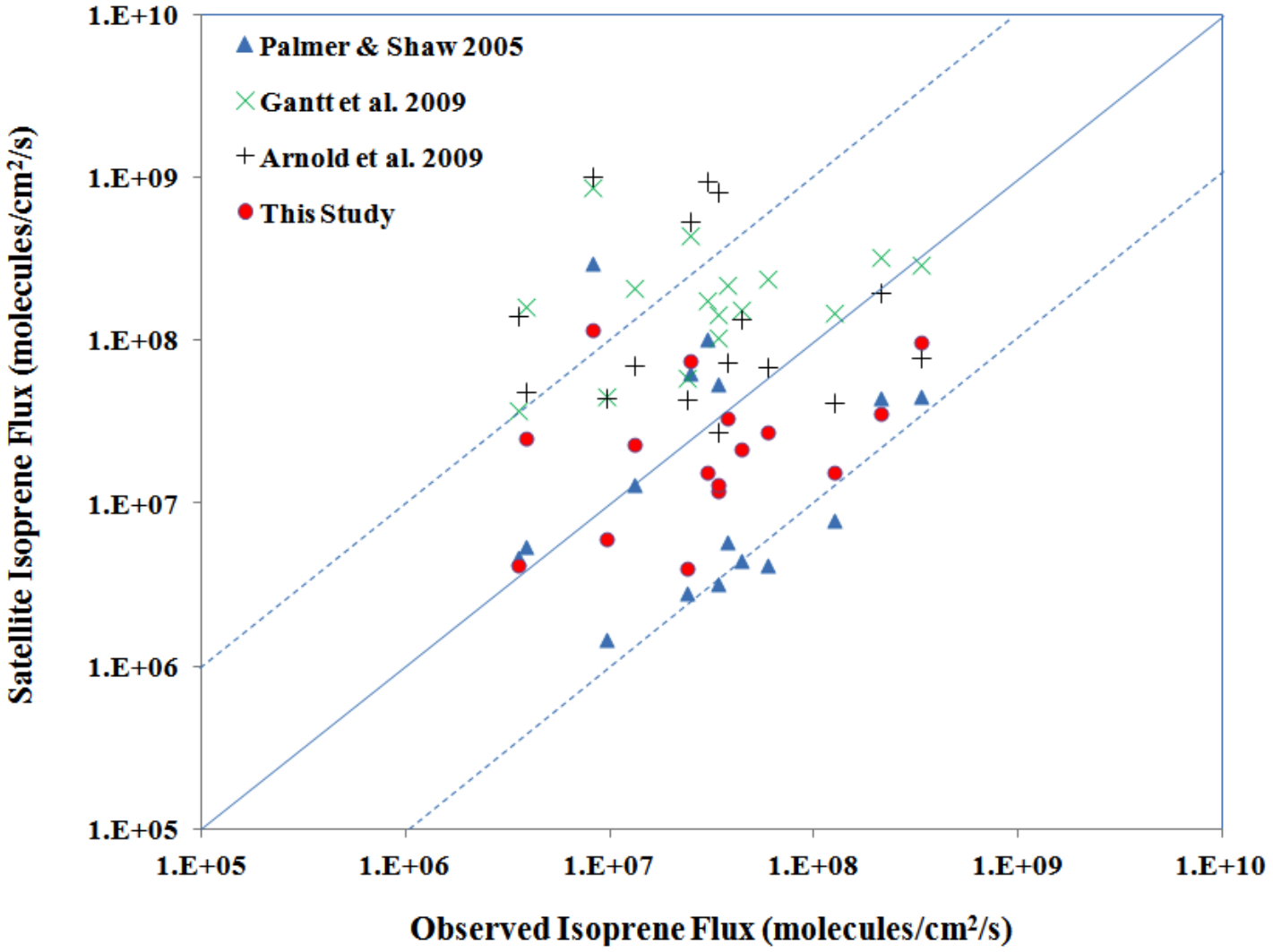
Calculate exchange coeff based on wind speed:

$$K_{AS} = 0.31 * U^2 ((391315 - 16213T + 2.67T^2 - 0.012T^3) / 660)^{-0.5}$$

U – surface wind speed; **T** – Sea surface Temperature

(Wanninkhof et al., 2004)

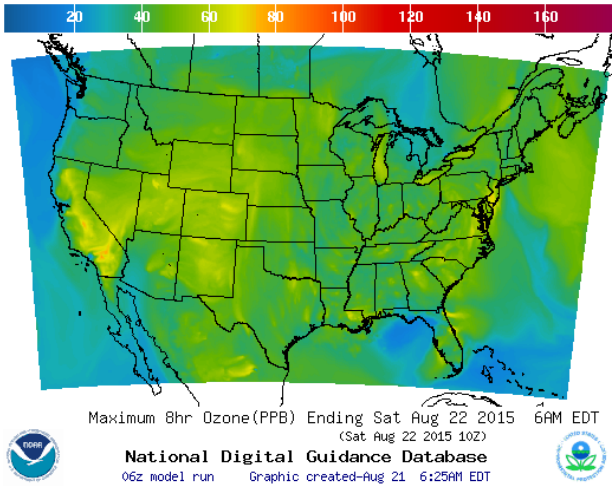
Isoprene Product Validation (Cont.)



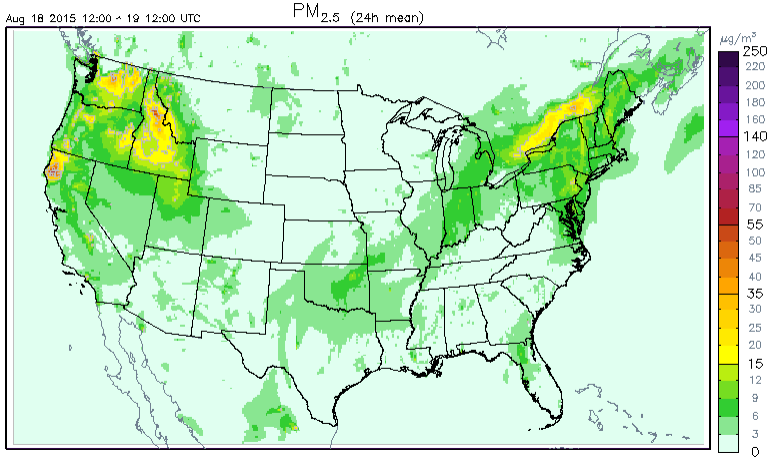
NOAA National Air Quality Forecast Capability (NAQFC)

- Developed by OAR/Air Resources Laboratory; Operated by National Weather Service (NWS) (PM: I. Stajner).
- Provides national numeric air quality guidance for ozone (operational product) and $PM_{2.5}$ (particulate matter with diameter < 2.5 μm);

O_3 Forecasting



$PM_{2.5}$ Forecasting

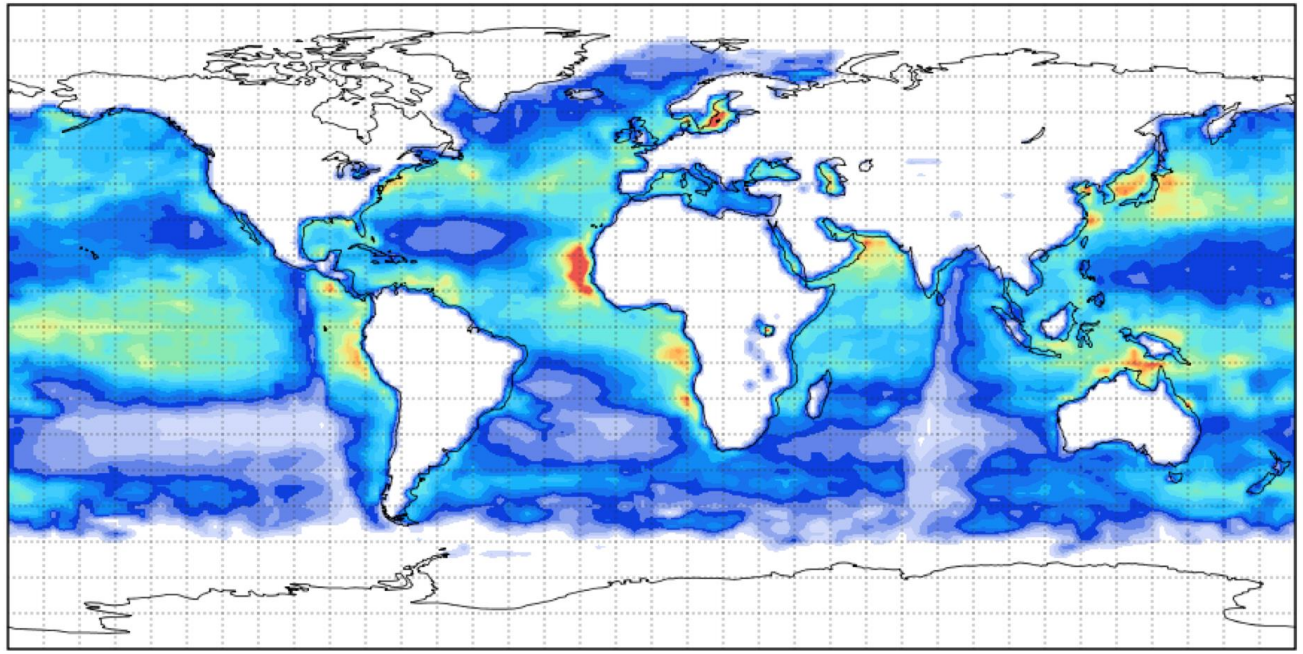


http://airquality.weather.gov/

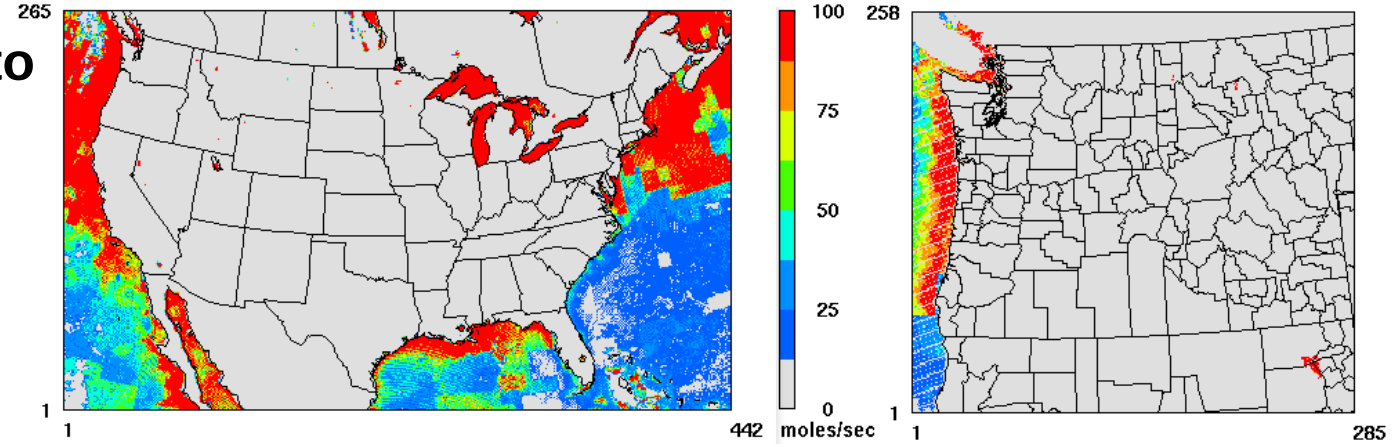
NAQFC is one of the major gateways to disseminate NOAA satellite observations and model prediction of air quality to the public.

VIIRS Isoprene applications: National and regional air quality forecasting

Global Isoprene (April 2014)



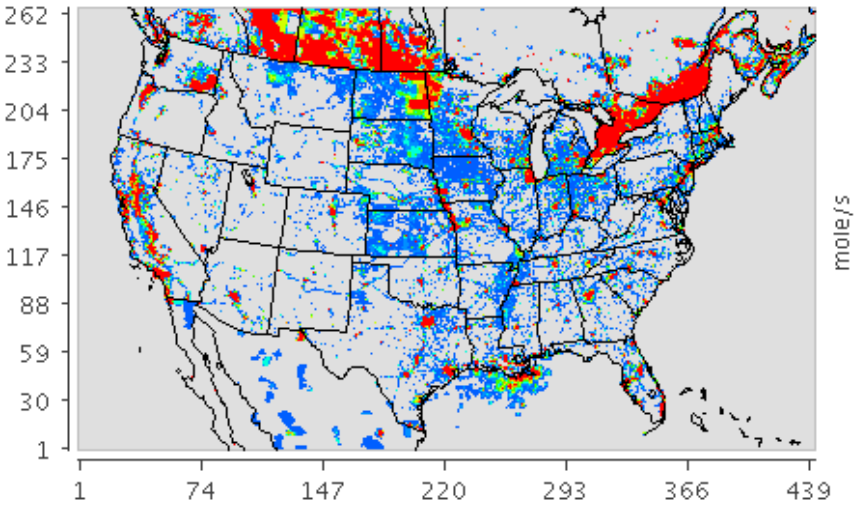
Isoprene into model domains



Application of VIIRS Isoprene in NAQFC

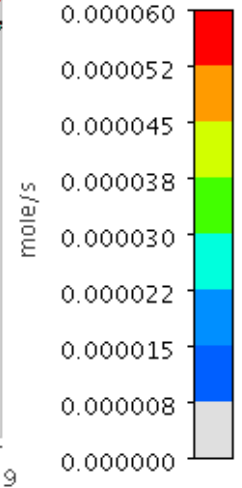
Since June 2018, VIIRS Isoprene product has been incorporated into ARL emission data to support NWS NAQFC operation.

Area Isoprene Emission (No VIIRS Data)

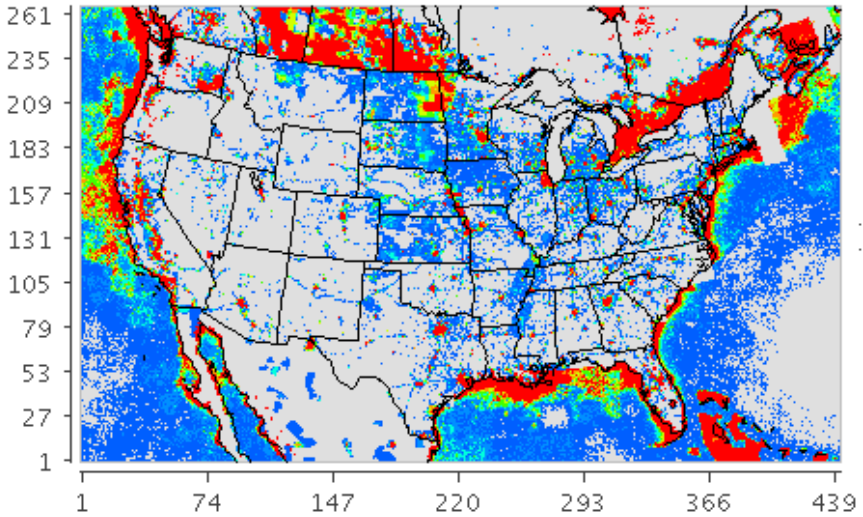


July 1, 2017 00:00:00 UTC

Min (1, 1) = 0.000, Max (45, 121) = 0.004



Isoprene Emission with VIIRS Data



July 1, 2017 00:00:00 UTC

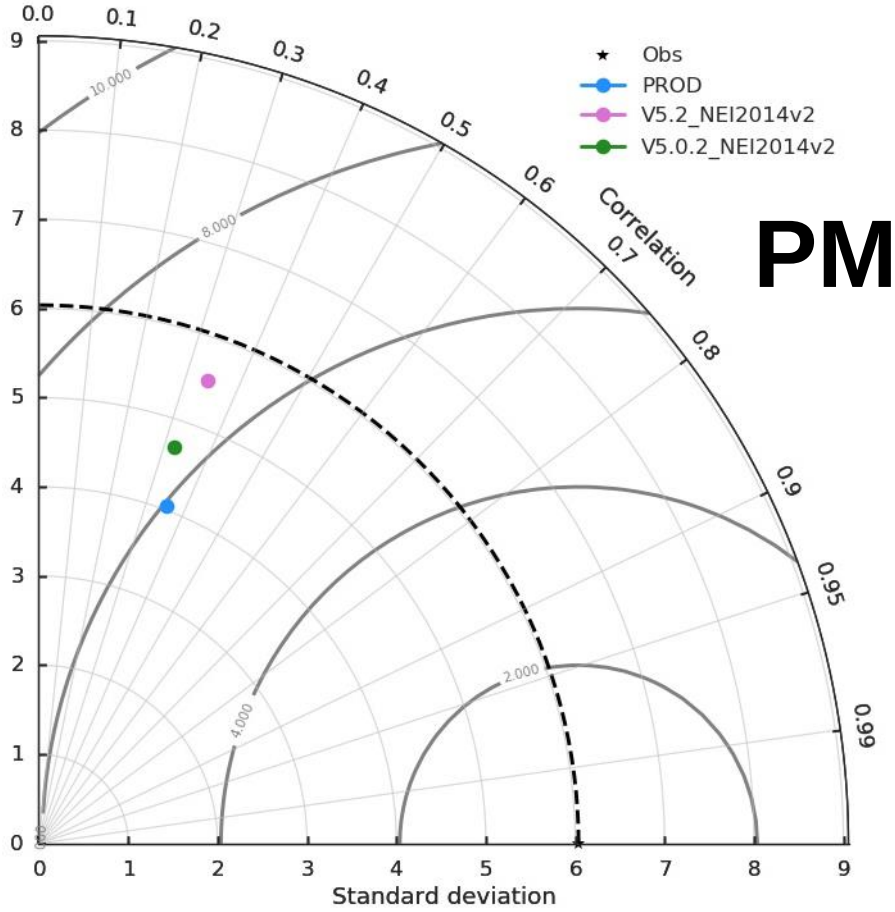
Min (381, 5) = 0.000000, Max (338, 52) = 0.006023

<u>VIIRS marine isoprene is complementary to terrestrial and anthropogenic emissions currently used in NAQFC.</u>

NAQFC 2018 Updates

Updates from the NEI2011 (Op.)

- Agriculture: NH_3 expanded with all related species;
- Mobile sources: MOVES2014v2.
- **Marine emissions (VIIRS) and Halogen chemistry.**
- Model updates: from Version 5.0.2 to V5.2



$PM_{2.5}$

(Courtesy of Pius Lee, Youhua Tang and Barry Baker)

NAQFC 2018 Updates

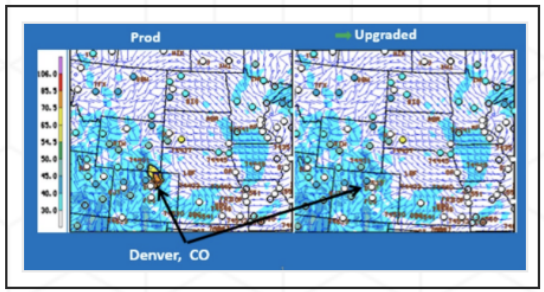
Search

ARL Updates NWS Forecast Model to Resolve High Wintertime Ozone Issue

April 2018

The atmospheric chemistry group within NOAA's Air Resources Laboratory (ARL) delivered new model packages and emission data to the National Weather Service (NWS) that, among other upgrades, resolved a long-term ozone forecasting issue: high wintertime ozone bias over oil/gas fields.

The operational forecasting system that provides real-time prediction of ozone and aerosols to our nation is the NWS's National Air Quality Forecast Capability, or NAQFC. For several years, forecasters have been



A Code Orange bad air quality forecast due to an erroneous ozone plume north of Denver on a winter day. Credit: NOAA

Serving the broad community

VIIRS Isoprene product released to "early adopter" users at a user workshop hosted by ARL, JPSS and NESDIS/STAR.

(Mitch Goldberg greeting users)

Workshop participants:

- NWS, OAR, NESDIS;
- Environment Canada
- World Meteorological Organization
- US Environmental Protection Agency,
- National Center for Atmospheric Research
- Department of Energy
- National Institute of Standards and Technology
- New York Department of Environmental Conservation
- Meteorological Agencies from Mexico, Japan, South Korea, India, and Chile.
- Universities (Georgia Tech, University of Iowa, University of Alabama, UMD etc);
- Private sector.

Summary & Future Plan

- JPSS offers unique marine emission products derived from VIIRS-SNPP ocean color data;
- VIIRS isoprene product has been incorporated into OAR/ARL emission data to support NWS NAQFC operations;
- Marine emission products, including isoprene, dimethyl sulfide (DMS), organic aerosols, are needed to support NWS Next-Generation Global Prediction System (NGGPS).